DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 310

SURFACE WATER SUPPLY OF THE UNITED STATES

1911

PART X. THE GREAT BASIN

PREPARED UNDER THE DIRECTION OF M. O. LEIGHTON

BY

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SURFACE WATER SUPPLY OF THE GREAT BASIN, 1911.

By F. F. HENSHAW, H. D. MCGLASHAN, and E. A. PORTER.

AUTHORIZATION OF WORK.

This volume is Part X of a series of 12 reports presenting results of measurements of flow made on certain streams in the United States during the calendar year 1911. The reports are listed in the following table:

Papers on surface water supply of the United States, 1911.

Part.[a]	No.	Title.
I	301	North Atlantic coast.
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[a] For the purpose of uniformity in the presentation of reports, a general plan has been agreed upon by the United States Reclamation Service, the United States Forest Service, the United States Weather Bureau, and the United States Geological Survey, according to which the area of the United States has been divided into 12 parts, whose boundaries coincide with natural drainage lines indicated by the parts of the report.

The data presented in these reports were collected by the United States Geological Survey under authority implied in the organic law (20 Stat. L., p. 394) which contains the following paragraph:

> *Provided*, That this officer [the Director] shall have the direction of the geological survey and the classification of public lands and examination of the geological structure, mineral resources, and products of the national domain.

The work was begun in 1888 in connection with special studies of water supply for irrigation.

Since the fiscal year ending June 30, 1895, successive sundry civil bills passed by Congress have carried the following item and appropriations:

> For gaging the streams and determining the water supply of the United States, and for the investigation of underground currents and artesian wells, and for the preparation of reports upon the best methods of utilizing the water resources.

Annual appropriations for the fiscal year ending June 30—

1895	$12,500
1896	20,000
1897 to 1900, inclusive	50,000
1901 to 1902, inclusive	100,000
1903 to 1906, inclusive	200,000
1907	150,000
1908 to 1910, inclusive	100,000
1911 to 1913, inclusive	150,000

In the execution of the work many private and State organizations have cooperated. Acknowledgments for such cooperation is made on page 15 and also in connection with the description of each station affected by the cooperative work.

PUBLICATIONS.

Measurements of stream flow have been made at more than 2,000 points in the United States and also at many points in small areas in Seward Peninsula and the Yukon-Tanana region, Alaska, and in the Hawaiian Islands. During 1911 gaging stations were maintained by the Survey and the cooperating organizations at about 1,500 points in the United States, and many discharge measurements were made at other points. In connection with this work data were also collected in regard to precipitation, evaporation, storage reservoirs, river profiles, and water power in many sections of the country and will be made available in the regular surface water supply papers from time to time. A complete list of the gaging stations maintained by the Survey to and including 1910 and a list of the papers relating to the water supply of the country has been published as Water-Supply Paper 280. An index to the reports containing stream-flow measurements prior to 1904 has been published as Water-Supply Paper 119.

For each calendar year there has been prepared a report embodying the stream-flow data collected during that year, which has been published either as a part of the annual report of the Director, as a bulletin, or as a water-supply paper, as shown by the following table:

Stream-flow data in reports of the United States Geological Survey.

[A=Annual Report; B=Bulletin; WS=Water-Supply Paper.]

Report.	Character of data.	Year.
10th A, pt. 2	Descriptive information only	
11th A, pt. 2	Monthly discharge	1884, to Sept., 1890.
12th A, pt. 2	do	1884 to June 30, 1891.
13th A, pt. 3	Mean discharge in second-feet	1884 to Dec. 31, 1892.
14th A, pt. 2	Monthly discharge (long-time records, 1871 to 1893)	1888 to Dec. 31, 1893.
B 131	Descriptions, measurements, gage heights, and ratings	1893 and 1894.
16th A, pt. 2	Descriptive information only	
B 140	Descriptions, measurements, gage heights, ratings, and monthly discharge (also many data covering earlier years).	1895.
WS 11	Gage heights (also gage heights for earlier years)	1896.
18th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge (also similar data for some earlier years).	1895 and 1896.
WS 15	Descriptions, measurements, and gage heights, eastern United States, eastern Mississippi River, and Missouri River above junction with Kansas.	1897.
WS 16	Descriptions, measurements, and gage heights, western Mississippi River below junction of Missouri and Platte, and western United States.	1897.
19th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge (also some long-time records).	1897.
WS 27	Measurements, ratings, and gage heights, eastern United States, eastern Mississippi River, and Missouri River.	1898.
WS 28	Measurements, ratings, and gage heights, Arkansas River and western United States.	1898.
20th A, pt. 4	Monthly discharge (also for many earlier years)	1898.
WS 35 to 39	Descriptions, measurements, gage heights, and ratings	1899.
21st A, pt. 4	Monthly discharge	1899.
WS 47 to 52	Descriptions, measurements, gage heights, and ratings	1900.
22d A, pt. 4	Monthly discharge	1900.
WS 65, 66	Descriptions, measurments, gage heights, and ratings	1901.
WS 75	Monthly discharge	1901.
WS 82 to 85	Complete data	1902.
WS 97 to 100	do	1903.
WS 124 to 135	do	1904.
WS 165 to 178	do	1905.
WS 201 to 214	do	1906.
WS 241 to 252	do	1907-8.
WS 261 to 272	do	1909.
WS 281 to 292	do	1910.
WS 301 to 312	do	1911.

NOTE.—No data regarding stream flow are given in the 15th and 17th annual reports.

The table which follows gives, by years and drainage basins, the numbers of the papers on surface-water supply published from 1899 to 1911. The data for any particular station will be found in the reports covering the years during which the station was maintained. For example, data for Machias River at Whitneyville, Me., 1903 to 1911, are published in Water-Supply Papers 97, 124, 165, 201, 241, 261, 281, and 301, which contain records for the New England streams from 1903 to 1911.

Numbers of water-supply papers containing results of stream measurements, 1899–1911.

	1899 a	1900 b	1901	1902	1903	1904
North Atlantic coast (St. John River to York River)	35	47, c 48	65, 75	82	97	d 124, e 125, f 126
South Atlantic coast and eastern Gulf of Mexico (James River to the Mississippi)	g 35, 36	48	65, 75	g 82, 83	g 97, 98	f 126, 127
Ohio River basin	36	48, h 49	65, 75	83	98	128
St. Lawrence River and Great Lakes	36	49	65, 75	i 82, 83	97	129
Hudson Bay and upper Mississippi River	36	49	j 65, 66, 75	j 83, 85	j 98, 99, 100	j 128, 130
Missouri River	k 36, 37	49, l 50	66, 75	84	99	130, m 131
Lower Mississippi River	37	50	j 65, 66, 75	j 83, 84	j 98, 99	j 128, 131
Western Gulf of Mexico	37	50	66, 75	84	99	132
Colorado River	n 37, 38	50	66, 75	85	100	133
Great Basin	38, p 39	51	66, 75	85	100	133, q 134
Pacific coast in California	38, r 30	51	66, 75	85	100	134
North Pacific coast	38	51	66, 75	85	100	135

	1905	1906	1907–8	1909	1910	1911
North Atlantic coast (St. John River to York River)	d 165, e 166, f 167	d 201, e 202, f 203	241	261	281	301
South Atlantic coast and eastern Gulf of Mexico (James River to the Mississippi)	f 167, 168	f 283, 204	242	262	282	302
Ohio River basin	169	205	243	263	283	303
St. Lawrence River and Great Lakes	170	206	244	264	284	304
Hudson Bay and upper Mississippi River	171	207	245	265	285	305
Missouri River	172	208	246	266	286	306
Lower Mississippi River	j 169, 173	j 205, 209	247	267	287	307
Western Gulf of Mexico	174	210	248	268	288	308
Colorado River	175, o 177	211	249	269	289	309
Great Basin	176, q 177	212, q 213	250, q 251	270, q 271	290	310
Pacific coast in California	177	213	251	271	291	311
North Pacific coast	s 177, 178	214	252	272	292	312

a Rating tables and index to Water-Supply Papers 35–39 continued in Water-Supply Paper 39.
b Rating tables and index to Water-Supply Papers 47–52 and data on precipitation, wells, and irrigation in California and Utah contained in Water-Supply Paper 52.
c Wissahickon and Schuylkill rivers to James River.
d New England rivers only.
e Hudson River to Delaware River, inclusive.
f Susquehanna River to Yadkin River, inclusive.
g James River only.
h Scioto River.
i Lake Ontario and tributaries to St. Lawrence River proper.
j Tributaries of Mississippi from east.
k Gallatin River.
l Loup and Platte rivers near Columbus, Nebr., and all tributaries below junction with Platte.
m Platte and Kansas rivers.
n Green and Gunnison rivers and Grand River above junction with Gunnison.
o Below junction with Gila.
p Mohave River only.
q Great Basin in California, excepting Truckee and Carson drainage basins.
r Kings and Kern rivers and south Pacific coast drainage basins.
s Rogue, Umpqua, and Siletz rivers only.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and run-off in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off in depth in inches, and acre-feet. The units used in this series of reports are second-feet, second-feet per square mile, run-off in depth in inches, and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the accompanying table of equivalents.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off, depth in inches," is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

An "acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. The term is commonly used in connection with storage for irrigation.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computations:

Table for converting discharge in second-feet per square mile into run-off in depth in inches over the area.

Discharge (second-feet per square mile).	Run-off (depth in inches).				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	0.03719	1.041	1.079	1.116	1.153
2	.07438	2.083	2.157	2.231	2.306
3	.11157	3.124	3.236	3.347	3.459
4	.14876	4.165	4.314	4.463	4.612
5	.18595	5.207	5.393	5.578	5.764
6	.22314	6.248	6.471	6.694	6.917
7	.26033	7.289	7.550	7.810	8.070
8	.29752	8.331	8.628	8.926	9.223
9	.33471	9.372	9.707	10.041	10.376

NOTE.—For partial month multiply the values for 1 day by the number of days.

Table for converting discharge in second-feet into run-off in acre-feet.

Discharge (second-feet).	Run-off (acre-feet).				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	1.983	55.54	57.52	59.50	61.49
2	3.967	111.1	115.0	119.0	123.0
3	5.950	166.6	172.6	178.5	184.5
4	7.934	222.1	230.1	238.0	246.0
5	9.917	277.7	287.6	297.5	307.4
6	11.90	333.2	345.1	357.0	368.9
7	13.88	388.8	402.6	416.5	430.4
8	15.87	444.3	460.2	476.0	491.9
9	17.85	499.8	517.7	535.5	553.4

NOTE.—For partial month multiply values for 1 day by the number of days.

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,317 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day equals 86,400 cubic feet.
1,000,000,000 (1 United States billion) cubic feet equals 11,570 second-feet for one day.
1,000,000,000 cubic feet equals 414 second-feet for one 28-day month.
1,000,000,000 cubic feet equals 399 second-feet for one 29-day month.
1,000,000,000 cubic feet equals 386 second-feet for one 30-day month.
1,000,000,000 cubic feet equals 373 second-feet for one 31-day month.
100 California miner's inches equals 18.7 United States gallons per second.
100 California miner's inches for one day equals 4.96 acre-feet.
100 Colorado miner's inches equals 2.60 second-feet.
100 Colorado miner's inches equals 19.5 United States gallons per second.
100 Colorado miner's inches for one day equals 5.17 acre-feet.
100 United States gallons per minute equals 0.223 second-foot.
100 United States gallons per minute for one day equals 0.442 acre-foot.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 foot equals 0.3048 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 5,280 feet.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot of water weighs 62.5 pounds.
1 cubic meter per minute equals 0.5886 second-foot.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76.0 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
$1\frac{1}{3}$ horsepower equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

EXPLANATION OF DATA.

For each regular current-meter gaging station the following data, so far as available, are given: Description of the station, list of discharge measurements, table of daily gage heights, table of daily discharge, table of monthly and yearly discharge and run-off. For stations located at weirs or dams the gage-height table is omitted.

In addition to statements regarding the location and installation of current-meter stations the descriptions give information in regard to any conditions which may affect the constancy of the relation of gage height to discharge, covering such points as ice, logging, shifting channels, and backwater; also information regarding diversions which decrease the total flow at the measuring section. Statements are also made regarding the accuracy and reliability of the data.

The table of daily gage heights records the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day, usually in the morning and in the evening. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. All gage heights affected by the presence of ice in the streams or by backwater from obstructions are published as recorded, with suitable footnotes. The rating table is not applicable for such periods unless the proper corrections to the gage heights are known and applied. Attention is called to the fact that the zero of the gage is placed at an arbitrary datum and has no relation to zero flow or the bottom of the river. In general the zero is located somewhat below the lowest known flow, so that readings of negative values shall not occur.

The discharge measurements and gage heights are the base data from which rating tables, daily discharge tables, and monthly discharge tables are computed.

The rating table gives, either directly or by interpolation, the discharge in second-feet corresponding to every stage of the river recorded during the period for which it is applicable. It is not published in this report, but can be determined from the tables of daily gage heights and daily discharge as follows:

First plot the discharge measurements for the current and earlier years on cross-section paper, with gage heights in feet as ordinates and discharge in second-feet as abscissas. Then tabulate a number of gage heights taken from the daily gage-height table for the complete range of stage given and the corresponding discharges for the days selected from the daily discharge table and plot the values on cross-section paper. The last points plotted will define the rating curve used and will lie among the plotted discharge measurements. After drawing the rating curve a table can be developed by scaling off the discharge in second-feet for each tenth foot of gage height. These values should be so adjusted that the first differences shall always be increasing or constant except for known backwater periods.

The table of daily discharge gives the discharge in second-feet corresponding to the observed gage heights as determined from the rating tables.

In the table of monthly discharge the column headed "Maximum" gives the mean flow, as determined from the rating table, for the day when the mean gage height was highest. As the gage height is the mean for the day, it does not indicate correctly the stage when the water surface was at crest height, and the corresponding discharge was consequently larger than given in the maximum column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow in cubic feet for each second during the month. On this the computations for the remaining columns, which are defined on page 11, are based.

The field methods used in the collection of the data presented in this series of reports are described in the introductory sections of Water-Supply Papers 261 to 272, inclusive, "Surface water supply of the United States, 1909."

Plates I and II show the average precipitation and run-off in the United States, as determined from the measurements of stream flow made by the Geological Survey and records of rainfall collected by the Weather Bureau.

Plate III shows typical gaging stations.

Plate IV shows current meters[1] used in the work.

ACCURACY AND RELIABILITY OF FIELD DATA AND COMPARATIVE RESULTS.

The accuracy of stream-flow data depends primarily on the natural conditions at the gaging station and on the methods and care with which the data are collected. Errors of the first group depend on the degree of permanency of channel and of permanency of the relation between discharge and stage.

Errors of the second class are due, first, to errors in observation of stage; second, to errors in measurements of flow; third, to errors due to misinterpretation of stage and flow data.

In order to give engineers and others information regarding the probable accuracy of the computed results, footnotes are added to the daily discharge tables, stating the probable accuracy of the rating tables used, and an accuracy column is inserted in the monthly discharge table. For the rating tables "well defined" indicates, in general, that the rating is probably accurate within 5 per cent; "fairly well defined," within 10 per cent; "poorly defined" or "approximate," within 15 to 25 per cent. These notes are very general and are based on the plotting of the individual measurements with reference to the mean rating curve.

The accuracy column in the monthly discharge table does not apply to the maximum or minimum nor to any individual day, but to the monthly mean. It is based on the accuracy of the rating, the

[1] See Hoyt, J. C., and others, Use and care of the current meter as practiced by the United States Geological Survey: Trans. Am. Soc. Civil Eng., vol. 66, 1910, p. 70.

TION

MAP OF UNITED STATES, SHOWING MEAN ANNUAL PRECIPITATION

Blue lines and figures indicate average annual precipitation in depth in inches

Prepared by Henry
mainly from data of the
United States Geologi
and United States We

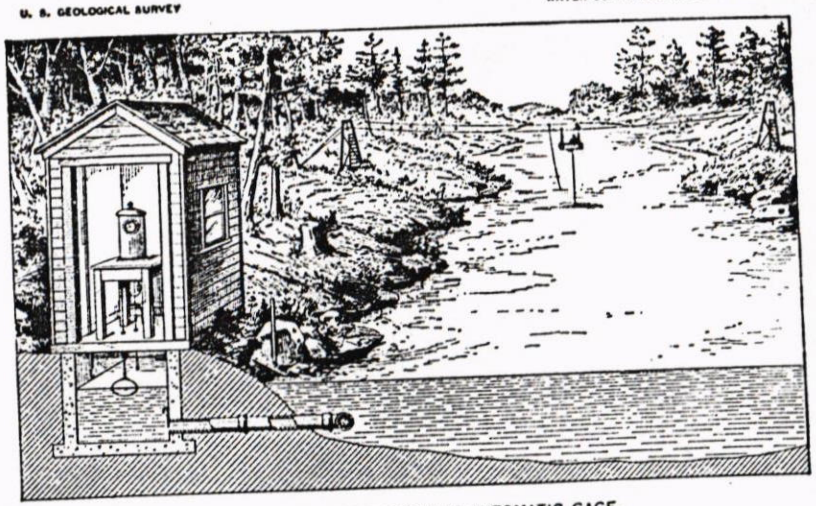
U. S. GEOLOGICAL SURVEY
ORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPERS 301 TO 312 PLATE II

MAP OF UNITED STATES, SHOWING MEAN ANNUAL RUN-OFF

Blue lines and figures indicate average annual run-off in depth in inches

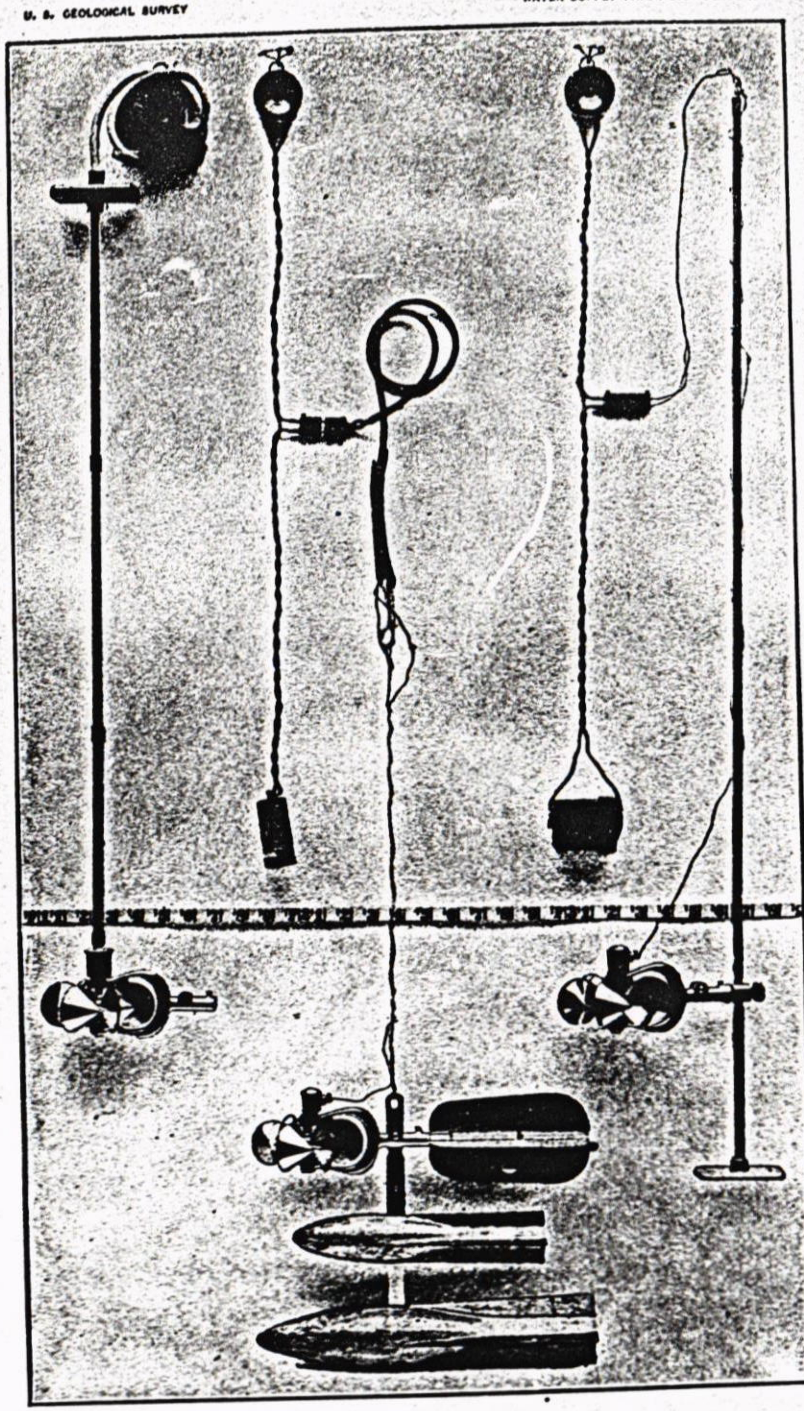
Prepared by Henry Gannett
mainly from data of the
United States Geological Sur



A. CABLE STATION, SHOWING AUTOMATIC GAGE.

B. FOR BRIDGE MEASUREMENT.

TYPICAL GAGING STATIONS.



SMALL PRICE CURRENT METERS.

probable reliability of the observer, and knowledge of local conditions. In this column A indicates that the mean monthly flow is probably accurate within 5 per cent; B, within 10 per cent; C, within 15 per cent; D, within 25 per cent. Special conditions are covered by footnotes.

Even though the monthly means for any station may represent with a high degree of accuracy the quantity of water flowing past the gage, the figures showing discharge per square mile and depth of run-off in inches may be subject to gross errors which result from including in the measured drainage area large noncontributing districts or omitting estimates of water diverted for irrigation or other use, and they should, therefore, be considered as only approximate, particularly for periods of irrigation or of low water. For these errors it is as a rule not feasible to make adequate correction.

In general the base data collected each year by the Survey engineers are published not only to comply with the law but to afford any engineer the means of examining and adjusting to his own needs the results of the computations. The table of monthly discharge is so arranged as to give only a general idea of the flow at the station and should not be used for other than preliminary estimates. The determinations of daily discharge allow more detailed studies of the variation in flow by which the period of deficiency may be determined.

It should be borne in mind that the observations in each succeeding year may be expected to throw new light on data already collected and published, and the engineer who makes use of the figures presented in these papers should verify all ratings and make such adjustments for earlier years as may seem necessary.

COOPERATION AND ACKNOWLEDGMENTS.

CALIFORNIA AND NEVADA.

Assistance has been rendered or records furnished by the following, to whom acknowledgment is due: W. M. Kearney, State engineer of Nevada; the United States Reclamation Service, through D. W. Cole, project engineer; the Office of Experiment Stations, United States Department of Agriculture, through F. L. Peterson, irrigation engineer; the United States Weather Bureau, through H. F. Alps, section director; the United States Forest Service, through W. L. Huber, district engineer; the Stone & Webster Engineering Corporation; the Bureau of the Los Angeles Aqueduct; and P. L. Sherman, jr. This cooperation is separately acknowledged in the station descriptions.

OREGON.

In 1905 the State legislature of Oregon passed an act providing for an annual appropriation of $2,500 for investigation of water resources in the State, and a like amount for the making of topographic maps, contingent upon an equal allotment by the United States Geological Survey for similar investigations.

In 1911 the legislature passed an act appropriating $20,000 for the purpose of completing the topographic map of the State of Oregon, making more extensive stream measurements and otherwise investigating and determining the water supply of the State. The State engineer represents the State in this cooperation and each year enters into a contract with the Director of the United States Geological Survey.

A statement of the expenditures of both parties under this agreement and the cost of the work is given in Water-Supply Paper 312, which contains the major portion of the results obtained in Oregon.

Special acknowledgment is due to John H. Lewis, State engineer of Oregon.

A number of irrigation companies have cooperated with the Survey in procuring the field data for stations in the Great Basin in Oregon, and some assistance of this character was rendered on practically all these stations during 1911. Acknowledgment is due to the Silver Valley Irrigation Co. for data on the stations on streams entering Harney Valley from the north; the Eastern Oregon Engineering Co., engineers for Wm. Hanley Co., for data on Donner und Blitzen River and its tributaries; Thomas & Walter, on stations near Denio; Warner Lake Irrigation Co., on stations in Warner Valley, and Lakeview Irrigation & Power Co., on stations in Goose Lake valley.

IDAHO.

The work in Idaho has been carried on in cooperation with the State since 1909. The State Land Board provides funds on behalf of the State and the State engineer acts as the agent for the State. In general, contracts were entered into between the Director of the Geological Survey and the State engineer at the beginning of each fiscal year. A statement of the expenditures of both parties and the cost of the work for the year 1911 is given in Water-Supply Paper 312, which contains the major portion of the results obtained in Idaho. Special acknowledgement is due to Mr. A. E. Robinson, State engineer, and to the Telluride Power Co.

UTAH.

The stream-gaging work in Utah during 1911 was carried on by the Geological Survey in cooperation with the State under contracts between the Director of the Survey and the State engineer in the same manner as in other States. Special acknowledgments are due to Mr. Caleb Turner, State engineer, and Mr. G. F. McGonagle, city engineer of Salt Lake City.

DIVISION OF WORK.

The field work in California and Nevada was carried on under the direction of W. B. Clapp and H. D. McGlashan, district engineers, by J. E. Stewart, F. C. Ebert, and James E. Jones, and by G. T. Peekema, a Forest Service hydrographer. The records were compiled and recommendations for estimates made by H. D. McGlashan, district engineer, and R. C. Rice, office engineer. The data were reviewed and computations made under the direction of R. H. Bolster, hydraulic engineer, by E. A. Porter, A. H. Tuttle, H. J. Dean, and M. I. Walters.

The field data in Oregon were collected under the direction of Fred F. Henshaw, district engineer, by R. W. Davenport, John Dubuis, and W. O. Harmon. The records were compiled and recommendations for estimates made under the direction of Fred F. Henshaw, by E. S. Fuller, office engineer. The data were reviewed and computations made under the direction of R. H. Bolster, hydraulic engineer, by E. A. Porter, A. H. Tuttle, and M. I. Walters.

The field data in Idaho were collected under the direction of E. C. La Rue and G. C. Baldwin, district engineers, assisted by O. W. Hartwell, A. B. Purton, Lynn Crandall, J. C. Dort, G. H. Canfield, and H. L. Stoner. The data were reviewed and computations made under the direction of R. H. Bolster, by E. A. Porter, A. H. Tuttle, and M. I. Walters.

The field data in Utah were collected under the direction of E. C. La Rue and G. C. Baldwin, district engineers, by O. W. Hartwell, J. C. Dort, Lynn Crandall, G. H. Canfield, A. B. Purton, and H. L. Stoner.

The computations were made and the completed data prepared for publication under the direction of R. H. Bolster, assisted by E. A. Porter, H. D. Padgett, H. J. Dean, and A. H. Tuttle.

The manuscript was edited by Mrs. B. D. Wood.

GREAT SALT LAKE DRAINAGE BASIN.

BEAR RIVER BASIN.

BEAR RIVER AT DINGLE, IDAHO.

Location.—In sec. 7, T. 14 S., R. 45 E., half a mile southeast of the Dingle railway station and 100 yards south of the railway track, 10 miles above the outlet of Bear Lake.

Records available.—May 9, 1903, to December 31, 1911.

Drainage area.—2,890 square miles.

Gage.—Inclined staff on right bank; datum unchanged since 1903.

Channel.—Bed composed of gravel; shifting; both banks fairly high, and not subject to overflow.

Discharge measurements.—Made from car and cable 30 feet below the gage.

Winter flow.—River is usually frozen over from about December to March, ice reaching a thickness of about 15 inches; ice smooth; anchor or needle ice unknown.

Diversions.—Several canals take water for irrigation above the station. During the spring of 1911 the Telluride Power Co. began to divert water from a point above the station into Mud or North Lake for storage, the water being returned to the river above the Alexander station. A station was established on the power canal in June, 1911 (see p. 19). On June 21, 1911, the Pegleg canal was carrying about 10 second-feet of water, the Dingle canal about 25 second-feet, and the Preston-Montpelier canal about 10 second-feet.

Accuracy.—Open-water records good; fairly accurate estimates of the flow under ice have been made.

Cooperation.—Maintained in cooperation with the State and the Telluride Power Co.

To make the records at Dingle comparable to those obtained previous to the spring of 1911 the water diverted by the Telluride canal must be added to the determined discharge of the river.

Discharge measurements of Bear River at Dingle, Idaho, in 1911.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
Jan. 24[a]	Lynn Crandall	4.04	167
May 13	O. W. Hartwell	6.08	1,510
26	Gilkison & Hughes	5.4	1,140
June 2	G. M. Gilkison	5.08	915
21	H. L. Stoner	6.3	1,730
July 22	....do	3.9	340
Aug. 14	....do	3.4	177
Oct. 3	....do	3.49	207

[a] Ice measurement.

Daily gage height, in feet, of Bear River at Dingle, Idaho, for 1911.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.65	5.00	4.10	6.80	5.20	5.40	4.60		3.00	3.50		
2						5.08		3.70			3.50	3.50
3		4.90		7.10		5.00	4.40		3.20	3.49		2.48
4	3.60	5.10	4.25		5.30	5.00	4.40	3.65		3.45	3.45	
5		5.15	4.30	7.10		5.00		3.60	3.10			3.48
6	3.70				5.40		4.40		3.10		3.50	
7		5.30	4.30	6.20		5.00		3.55		3.45		3.52
8	3.70						4.25		3.10	3.45	3.50	
9		5.10		5.70	5.75	5.10	4.15	3.50				3.60
10			4.50			5.60	4.10	3.70	3.10	3.50	3.50	
11					6.00	5.60	4.00					3.62
12	3.70	4.70	5.10	5.30			3.90		3.25	3.50	3.50	
13					6.08			3.50			3.60	3.70
14		4.55	5.80	5.20	6.15	5.70	4.10	3.40	3.30			
15	3.70	4.55				6.00				3.50		3.70
16			5.60	5.00	6.20		4.00	3.30			3.55	
17	3.80	4.40	5.40			5.90			3.30			3.75
18			5.10		6.10		4.00	3.20			3.55	
19		4.40		4.80		6.10		3.10		3.45	3.60	
20	3.75		4.80		6.10		4.00		3.30		4.10	3.80
21	3.80				6.00	6.30		3.10		3.50		
22			5.20	4.80			3.90		3.30	3.45	3.90	3.72
23	3.90	4.30		4.90	5.90	5.15	3.85	3.10				
24	4.04		5.50						3.30		3.50	3.85
25		4.30			5.20	6.10	3.70	3.00		3.50	5.00	
26	3.85	4.30	7.90	4.90	5.40							
27			8.20		5.80	5.65	3.80	3.00	3.45	3.50	3.40	3.95
28	3.95		8.00	5.10								
29			8.10	5.15	5.80	5.00	3.70	3.00	3.40		3.40	3.90
30			6.80			4.95			3.45	3.50		
31							3.70					3.90

NOTE.—Relation of gage height to discharge affected by ice Jan. 1 to about the middle of March and about Dec. 1 to 31. Gage height Nov. 25 not considered correct.

Daily discharge, in second-feet, of Bear River at Dingle, Idaho, for 1911.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	520	185	2,180	886	1,010	606	268	89	207	207
2	498	200	2,320	905	824	562	268	110	206	207
3	475	215	2,470	925	781	517	260	132	204	200
4	560	230	2,470	944	781	522	252	121	194	194
5	500	245	2,470	977	781	522	236	110	194	200
6	625	245	2,040	1,010	781	522	229	110	194	207
7	660	245	1,610	1,090	781	490	222	110	194	207
8	610	268	1,410	1,160	810	459	214	110	194	207
9	560	291	1,210	1,240	840	420	207	110	200	207
10	503	315	1,120	1,340	1,150	400	268	110	207	207
11	446	347	1,030	1,440	1,150	360	248	127	207	207
12	390	380	944	1,480	1,170	319	228	144	207	207
13	360	412	915	1,510	1,170	364	207	150	207	236
14	330	445	896	1,560	1,220	408	180	155	207	231
15	330	477	831	1,580	1,450	388	168	155	207	227
16	302	510	776	1,610	1,410	367	155	155	204	222
17	275	542	742	1,560	1,370	369	144	155	201	222
18	275	575	708	1,520	1,460	371	132	155	198	222
19	275	607	674	1,520	1,540	373	110	155	194	236
20	268	639	674	1,520	1,630	375	110	155	200	420
21	260	748	674	1,440	1,720	357	110	155	207	380
22	252	857	674	1,400	1,300	340	110	155	194	340
23	245	954	724	1,360	874	322	110	155	198	296
24	245	1,050	724	1,150	1,210	295	100	155	202	252
25	245	2,180	724	944	1,550	268	89	168	207	207
26	245	3,310	724	1,010	1,380	286	89	181	207	194
27	225	3,650	777	1,290	1,210	303	89	194	207	180
28	205	3,430	830	1,290	1,010	286	89	187	207	180
29		3,540	857	1,290	808	268	89	180	207	180
30		2,180	872	1,200	781	268	89	194	207	180
31		2,180		1,110		268	89		207	

NOTE.—Daily discharge determined as follows: Feb. 1 to Mar. 10 from ice curve based on measurement made Jan. 24; Mar. 11 to 19, discharge gradually increased to allow for effect of melting of ice; Mar. 20 to 27, indirect method for shifting channels used; Mar. 28 to May 13, from fairly accurate curve; May 14 to July 21, by indirect method for shifting channels; July 22 to Nov. 30, from a well-defined rating curve. Discharge interpolated for days for which gage heights are missing except Nov. 21, which was estimated. Note the effect of diversion of water into Bear Lake inlet canal from May 24 to July 18. The discharge of the canal has not been added to the above values. (See p. 20.)

Monthly discharge of Bear River at Dingle, Idaho, for 1911.

[Drainage area, 2,890 square miles.]

Month.	Discharge in second-feet.				Run-off.		Accuracy.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.	
January			183	0.063	0.07	11,300	D
February			385	.133	.14	21,400	C.
March	3,650		1,010	.349	.40	62,100	B.
April	2,470	674	1,170	.405	.45	69,600	A.
May	1,610	886	1,270	.453	.52	78,100	B.
June	1,720	781	1,130	.481	.54	67,200	B.
July	606	268	386	.164	.19	23,700	B.
August	268	89	166	.057	.07	10,200	A.
September	194	89	145	.050	.06	8,630	B.
October	207	194	202	.070	.08	12,400	A.
November		80	229	.079	.09	13,600	A.
December			200	.069	.08	12,300	C.
The year	3,650		540	.196	2.69	391,000	

NOTE.—The determinations of discharge per square mile and run-off depth in inches include the diversion above station into Bear Lake inlet canal. All other columns do not include this diversion, and hence, to determine the available water above the diversion, the discharge in table on page 20 must be added.

Discharge Jan. 1 to 31 and Dec. 1 to 31 estimated, because of ice, from climatologic records, discharge of Bear River at Preston, and measurement Jan. 24, 1911.

BEAR (MUD) LAKE INLET CANAL AT DINGLE, IDAHO.

Location.—About three-fourths of a mile south of Dingle, Idaho, and about 2½ miles below the intake of the canal, in sec. 13, T. 14 S., R. 44 E.

Records available.—June 21 to December 31, 1911.

Gage.—Vertical staff about one-fourth of a mile above the point where the canal crosses the road leading south from Dingle.

Channel.—Shifting; the section narrows at the footplank from which discharge measurements are made to half the width of the canal, the narrow section being about 100 feet long. Both banks are high.

Discharge measurements.—Made from a foot plank 3 feet upstream from a small flume across the ditch about 75 feet below the gage.

Cooperation.—Station maintained in cooperation with the State of Idaho and the Telluride Power Co.

The records at this station will indicate the amount of water diverted by the Telluride Power Co. from Bear River for storage in the branch of Bear Lake known as Mud Lake. The amount of water thus diverted should be added to the discharge of the Bear at Dingle to make the records for that station comparable with those made previous to 1911.

Discharge measurements of Bear Lake inlet canal near Dingle, Idaho, in 1911.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
May 27	Telluride Power Co.	....	280
June 21	H. L. Stoner	5.0	339
July 5	Telluride Power Co.	4.40	262
22	H. L. Stoner	2.5	[a]3

[a] Estimated.

Daily gage height, in feet, and discharge, in second-feet, of Bear Lake inlet canal near Dingle, Idaho, for 1911.

[R. S. Hughes, observer.]

Day.	May.		June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1	....	....	4.6	250	4.5	230
2	....	....	4.6	250	4.5	230
3	....	....	5.2	405	4.5	230
4	....	....	5.2	405	4.5	230
5	....	....	5.2	405	4.5	230
6	....	....	5.2	405	4.4	209
7	....	....	5.2	405	4.4	209
8	....	....	5.2	405	4.3	189
9	....	....	5.2	405	4.2	170
10	....	....	4.6	250	4.2	170
11	....	....	.0	0	4.2	170
12	....	....	.0	0	4.1	152
13	....	....	.0	0	3.7	92
14	....	....	.0	0	3.2	38
15	....	....	.0	0	3.2	38
16	....	....	.0	0	3.1	31
17	....	....	.0	0	3.1	31
18	....	....	5.1	348	3.1	31
19	....	....	5.1	348	....	3
20	....	....	5.1	348	....	3

Daily gage height, in feet, and discharge, in second-feet, of Bear Lake inlet canal near Dingle, Idaho, for 1911—Continued.

Day.	May.		June.		July.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
21	....	....	5.0	340	....	3
22	....	....	4.9	317	....	3
23	....	....	5.1	363	....	....
24	4.1	150	5.0	340	....	....
25	4.1	150	4.9	317	....	....
26	4.8	310	4.9	317	....	....
27	.0	0	4.9	317	....	....
28	.0	0	4.9	317	....	....
29	.0	0	4.9	317	....	....
30	4.1	150	4.6	251	....	....
31	5.2	405	....	....	....	....

NOTE.—Gage-height records May 24 to June 20 derived by comparison between United States Geological Survey and Telluride Power Co.'s gages; they are probably liable to some error. Gage heights June 21 to July 18 read from the United States Geological Survey gage. Water turned out of the canal July 18, although, as shown by the discharge measurement July 22, there was some seepage discharge subsequent to July 18. The canal was not in operation in 1911 prior to May 24 or subsequent to July 18.

Daily discharge determined from a rating curve not well defined. Discharge July 19 to 22 estimated. There may also have been a few second-feet discharge subsequent to July 22, but the assumption has been made that the discharge was zero after July 22.

Monthly discharge of Bear Lake inlet canal near Dingle, Idaho, for 1911.

Month.	Discharge in second-feet.			Run-off (in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
May	405	0	37.6	2,310	C.
June	405	0	261	15,500	B.
July	230	0	86.8	5,340	B.

NOTE.—To determine the total discharge of Bear River above Bear Lake inlet canal add the above determination to the discharge at the Dingle gaging station, p 19.

BEAR RIVER AT ALEXANDER, IDAHO.

Location.—About half a mile upstream from the post office at Alexander, Idaho, in secs. 17 and 18, T. 9 S., R. 41 E., 6 miles above the Telluride Power Co.'s plant near Grace, Idaho, and 4 miles above the intake of the Last Chance canal; it is 30 miles below the point where the outlet of Bear Lake flows into Bear River.

Records available.—March 27 to December 31, 1911.

Drainage area.—Not measured.

Gages.—Gage No. 1 is an inclined staff near the house of C. B. Wilson on the right bank about half a mile from the railroad station at Alexander. Gage No. 2 is about 1,000 feet downstream from gage No. 1 on the right bank and has been read in conjunction with gage No. 1 since November 15, 1911.

Channel.—Stream bed composed of fine gravel and sand; moss grows at the measuring section during the summer and fall and causes backwater at gage No. 1.

Discharge measurements.—Made from a cable and car near gage No. 1.

Winter flow.—Ice present during winter months.

Accuracy.—Records fair.

Cooperation.—Maintained in cooperation with Telluride Power Co. and State of Idaho.